4th U.S.-China Energy Efficiency Forum September 25, 2013

Compiled Presentations from Track 1, Breakout Session 2/Afternoon

High Performance Buildings

BERKELEY LAB
Lawrence Berkeley National Laboratory

Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

Collaboration on Building Code and Labeling System

Wei Feng

China Energy Group

Lawrence Berkeley National Laboratory

September 25, 2013

Building Energy Efficiency Code and S

Concept

- Assist China develop commercial and residential building codes
- Disseminate building simulation tools (e.g. DOE-2) to China for building code development
- Help China to develop a window rating and labeling program

Opportunity

- Evaluate energy savings of China's new commercial building code (GB50189-2013, 65% savings based on the 1980's baseline)
- Bring tools developed in the U.S. to China's building code development

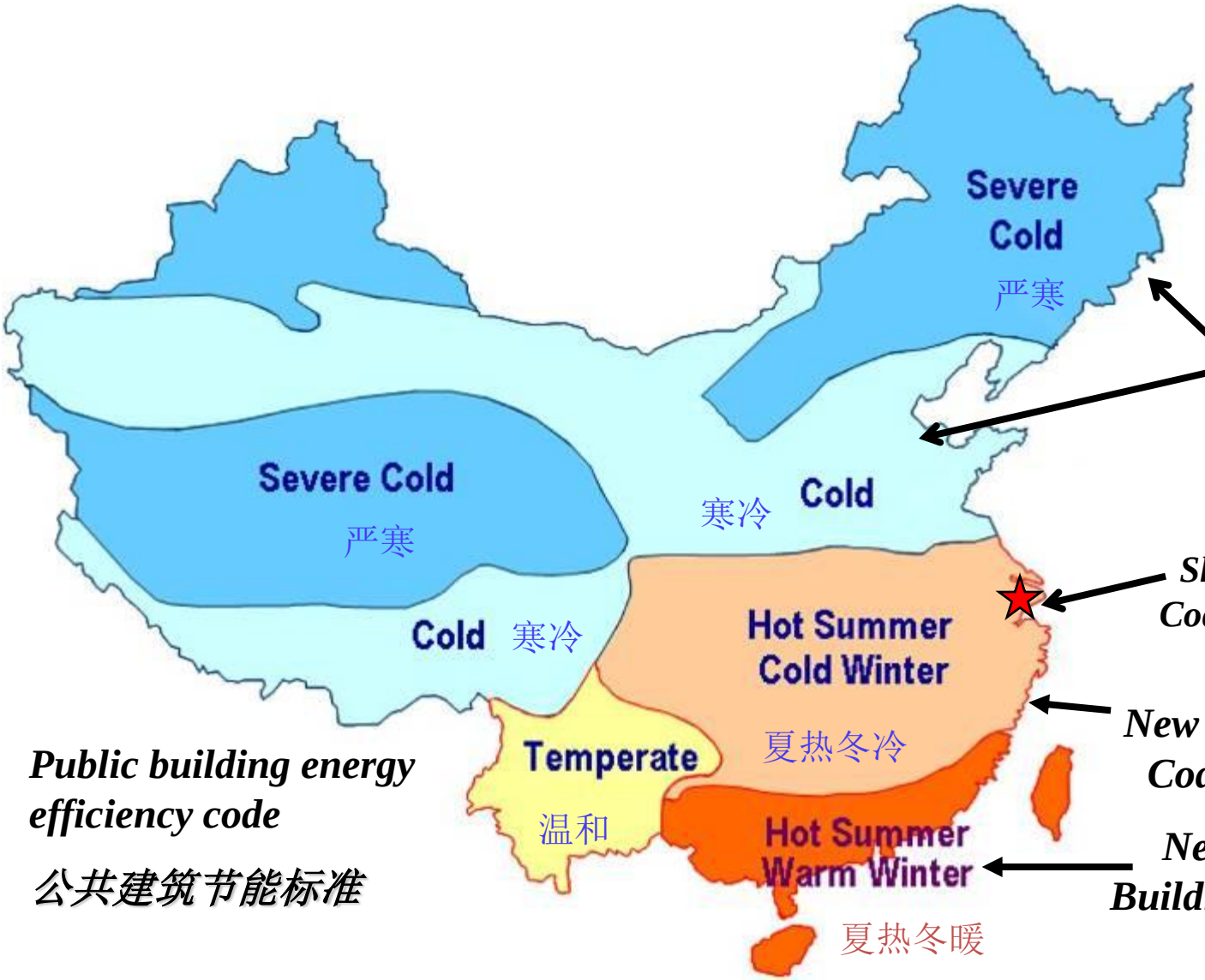
Successes

- Assisted drafting the first national building energy standard (GB50189-2005) development
- Participated in the development of residential energy standards for the Hot Summer Cold Winter region (JGJ134-2001)
- Help China setup a pilot window rating and labeling program, drawn from U.S NFRC. Pilot location was in Guangzhou province.
- Provided training of DOE-2 and other building simulation software

Collaborators:

- China Academy of Building Research (CABR), Guangdong Institute of Building Research

Buildings: Training in Developing New Building Codes
建筑行业：新建筑标准开发培训



Improved New Heating Zone Residential Building Code 改进的新供热区民用建筑标准

Shanghai Commercial Code 上海商业建筑标准

New Residential Building Code 新民用建筑标准

New Residential Building Code 新民用建筑标准

Public building energy efficiency code

公共建筑节能标准

Building Energy Efficiency Collaboration with China

- US-China Agenda 21 energy efficient demonstration office building in Beijing; 中美21世纪节能示范办公楼 (美国能源部中国科技部合作项目,1998年始,2003年底完成)
- Establishment of energy efficiency design standard for residential buildings in the HotSummer Cold-Winter Region in Central China (promulgated Oct. 2001); 协助制定夏热冬冷地区住宅节能设计标准 (2001年10月颁布)
- Establishment of energy efficiency design standard for residential buildings in the HotSummer Warm-Winter Region in South China (promulgated Oct. 2003); 协助制定夏热冬暖地区住宅节能设计标准(2003年10月颁布)
- Development of national energy efficiency design standard for public buildings (expected completion end 2004); 协助制定国家公共建筑节能设计标准(2004年底完成)
- Pilot project on labeling and rating system for energy efficient windows (2002-2005), with demonstration project in Guangdong Province (2004-5). 节能门窗标签分级试验性计划 (2004-2005), 广东省试点项目(2004-2005)
- US-China Joint Working Group on Green Building Rating System in support of a Green 2008 Beijing Olympics (start 2002). 中美绿色奥运合作联合工作组绿色奥运建筑评估体系(2002年始)

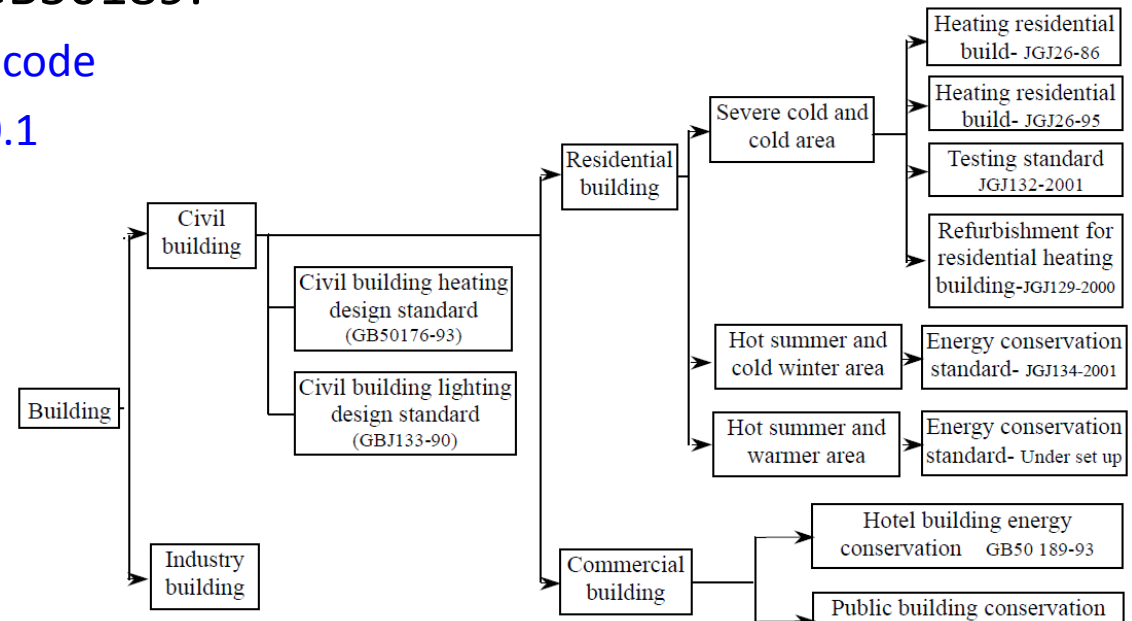
Building Code Structure

Building codes in China:

- National level: one commercial building code (GB50189), and three residential building code (JGJ 26, 134, 75) – defined on climate zone basis
- Local level: provinces can have their own building code, some provincial level codes are stringent than national level code (e.g. Tianjin, Shanghai, Jiangsu..)

Commercial building code -- GB50189:

- China's commercial building code
  - equivalent to ASHRAE 90.1
- First released in 1993
  with initial focus on hotel
- Last update in 2005
- New code will be release
  at the end of 2013



Source: Wu 2003

Commercial building code

Commercial building code -- GB50189:

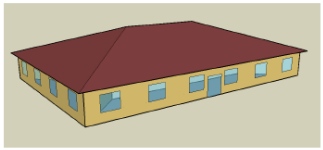
- Use 1980's commercial building characteristics as baseline (100%)
- Last update in 2005 achieved 50% energy savings from 1980's baseline
- New update in 2013 aims to achieve 65% energy savings → To be validated!

Importance of commercial building code

- Commercial building floor space increases from 2.8 billion m^2 (1996) to 7.1 billion m^2 (2008). Approximately, 0.5 billion m^2 new construction was built per year.
- Per capital, increases from 7.4 m^2/person (1996) to 11.5 m^2/person (2008)
- Will continue to increase in next 20~30 years because of fast urbanization

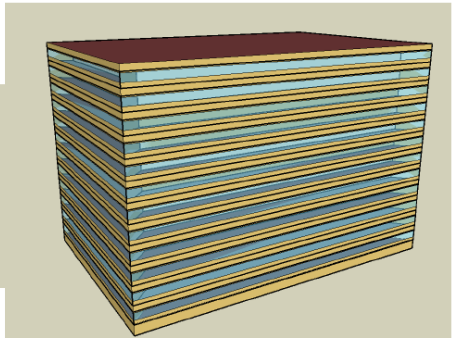
Reference Buildings – Models to Support Building Codes

Office Buildings

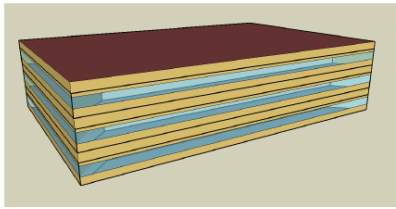


Small Office
1 floor, 5,500 ft²

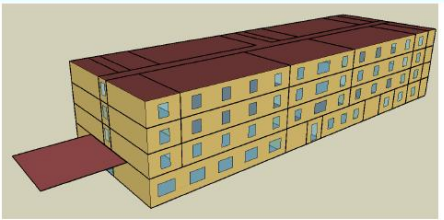
Large Office
12 floors, 498,588 ft²



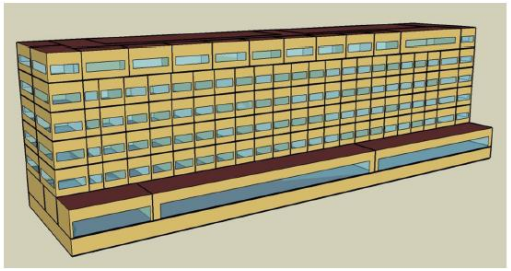
Medium Office
3 floor, 53,630 ft²



Lodging

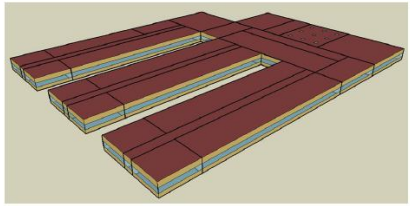


Small hotel
4 floors, 43,200 ft²



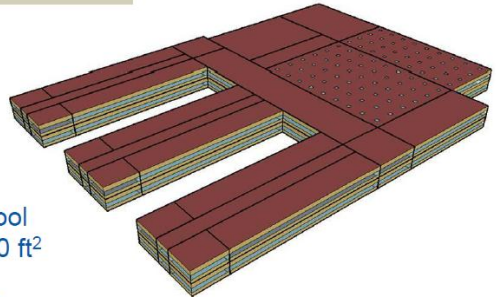
Large hotel
6 floors, 122,120 ft²

Schools



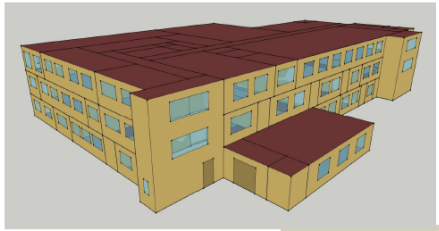
Primary School
1 floor, 73,960 ft²

16 X 16 X 3 = 768 models!

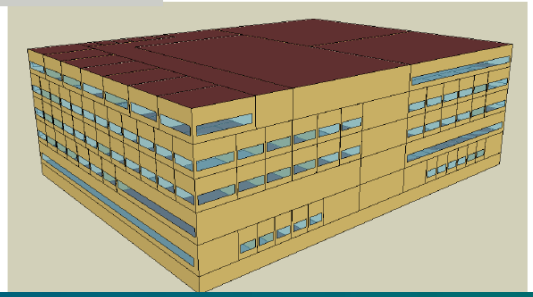


Secondary School
2 floors, 210,890 ft²

Healthcare



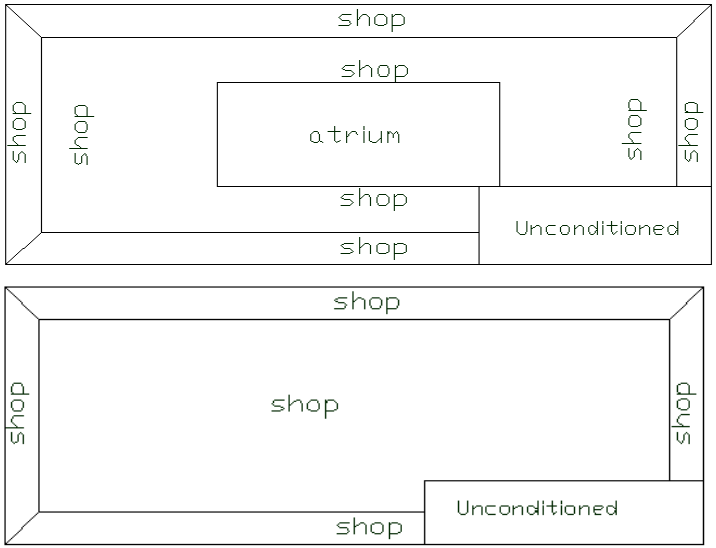
Outpatient Healthcare
3 floors, 40,946 ft²

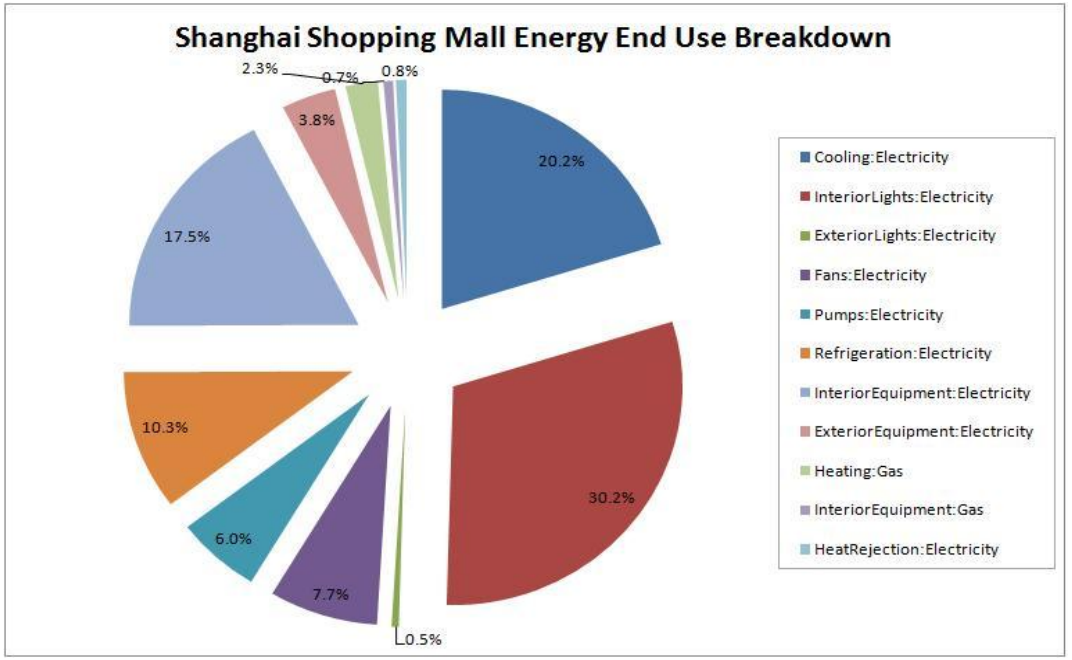


Hospital
5 floors, 241,351 ft²

Reference Buildings – Models to Support Building Codes

- A Chinese shopping mall reference prototype developed by LBNL and its Chinese partners
- LBNL is working with CABR to identify key parameters to conduct reference building survey and modeling.





Thank You!

Questions?

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Building Energy Codes Development and Enforcement: Progress and Comparative Lessons

Sha Yu and Meredydd Evans

Pacific Northwest National Laboratory

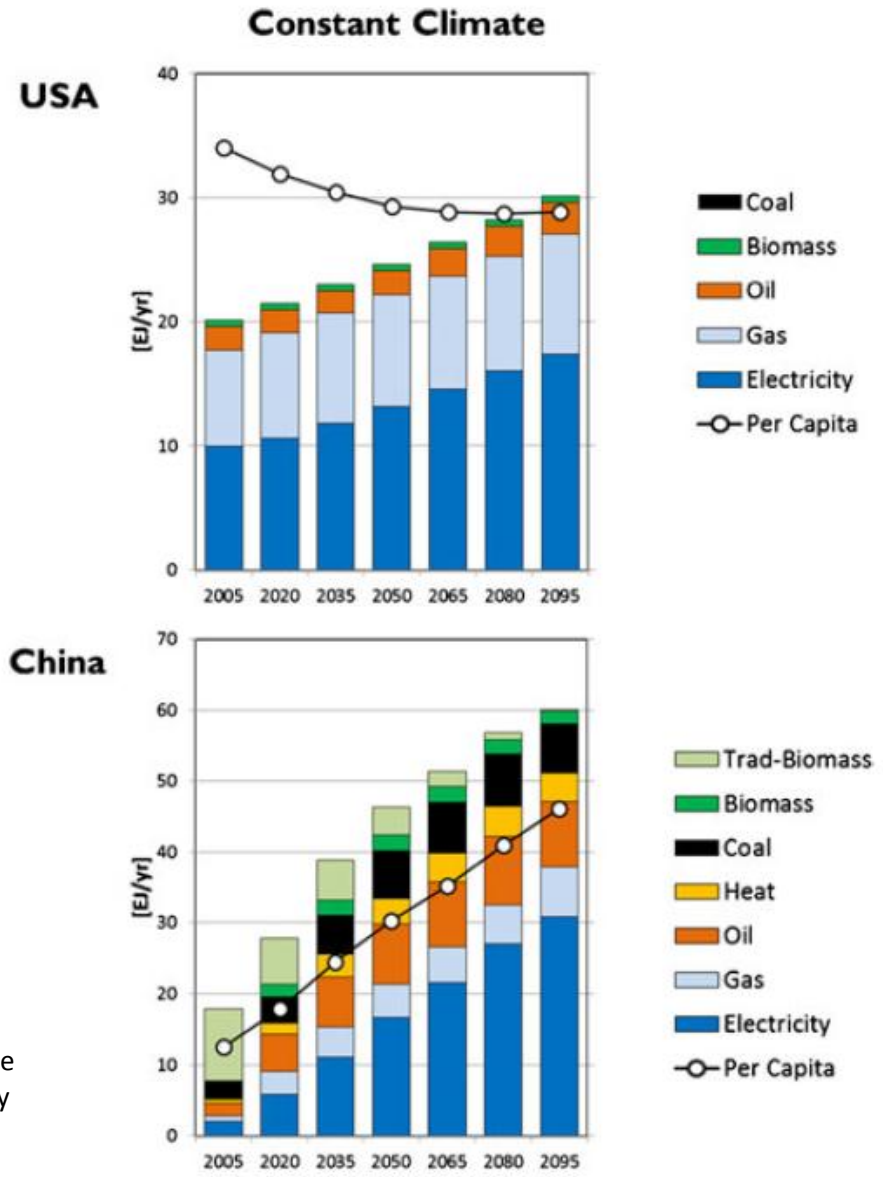
Fourth U.S.-China Energy Efficiency Forum
September 25, 2013

Overview

- Building energy use and codes impacts
- Building codes development and enforcement
  - Rural energy code in China
  - Enforcement system in China and the U.S.
- Lessons learned
- Market opportunities

Building Energy Demand in the U.S. and China

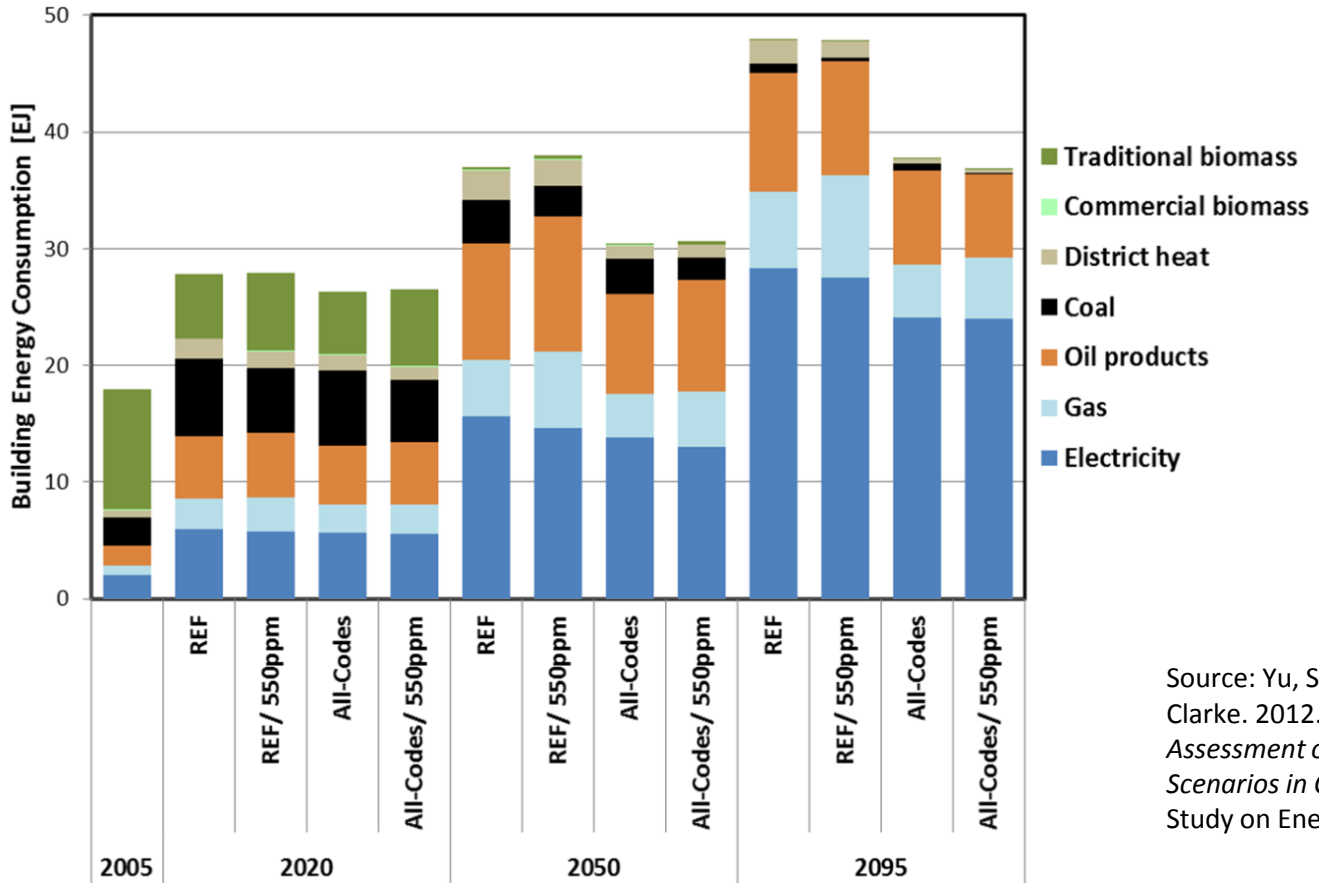
- Buildings in the U.S. and in China will experience increasing share of electricity during the 21st century.
- Per capita energy demand continuing to increase in China over the century, while per capita energy demand in the U.S. steadily decreasing.
- Overall development of fuel mix in the buildings sectors between the two countries will continue to be very different.



Source: Zhou, Y., Eom, J., and Clarke, L. (2013). The effect of global climate change, population distribution, and climate mitigation on building energy use in the U.S. and China. *Climatic Change*, 1-14.

Impacts of building codes and climate policy in China

- Energy codes could significantly reduce building energy use.
- Economy-wide carbon policy has a limited effect on building energy demand and direct CO_2 emissions.
- High compliance is essential for any noticeable impact.

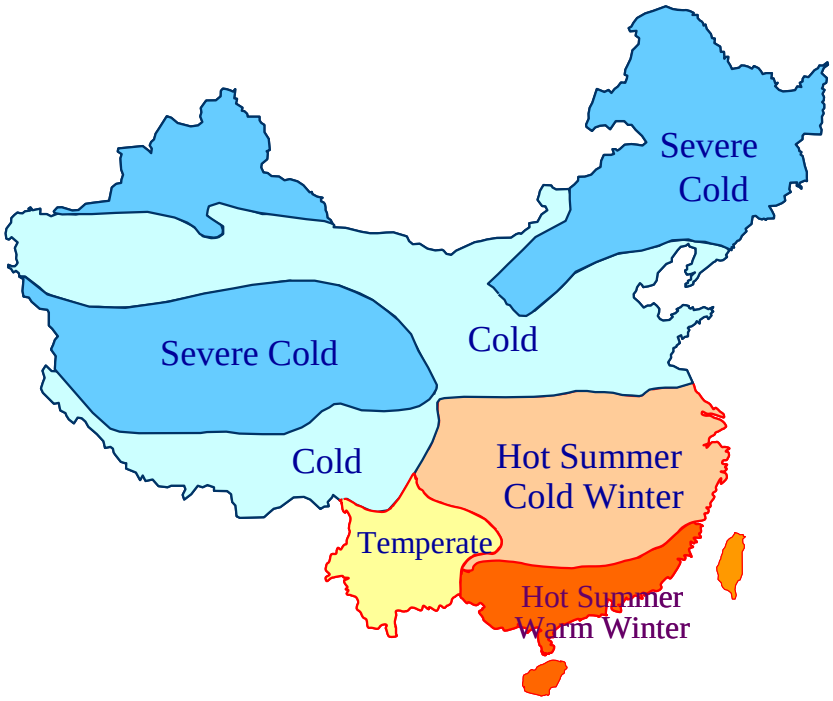


Source: Yu, S., J Eom, Y Zhou, M Evans, and L Clarke. 2012. *A Long-term, Integrated Impact Assessment of Alternative Building Energy Code Scenarios in China*. The 2012 ACEEE Summer Study on Energy Efficiency in Buildings.

Building Energy Codes in China

- China began to adopt building energy codes in the 1980s.
- Now there is one code for commercial buildings.
- Three other codes cover large residential buildings in different climate zones: severe cold/cold, hot summer-cold winter and hot summer-warm winter.
- Energy code for rural buildings went into effective in May 2013.

Map of China's Climate Zones



Energy Code for Rural Buildings

- Despite fast urbanization, rural buildings still account for a big share of total building stock in the near term (40% today and around 25% at 2030).
- Rural buildings demand more energy than urban buildings at least in the near term.
- Designs and energy uses in urban and rural buildings are different.

Contents of the Rural Energy Code

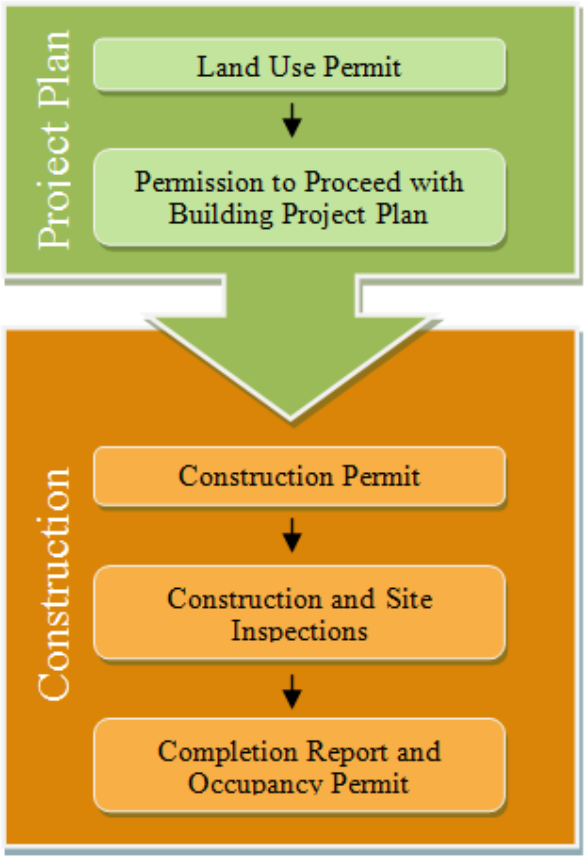
- Architectural layout and energy efficiency design
- Building envelope insulation
- Heating and ventilation system
- Lighting
- Renewable energy use
  - Solar, biomass, geothermal, etc.

Rural Building Energy Codes: Key Considerations

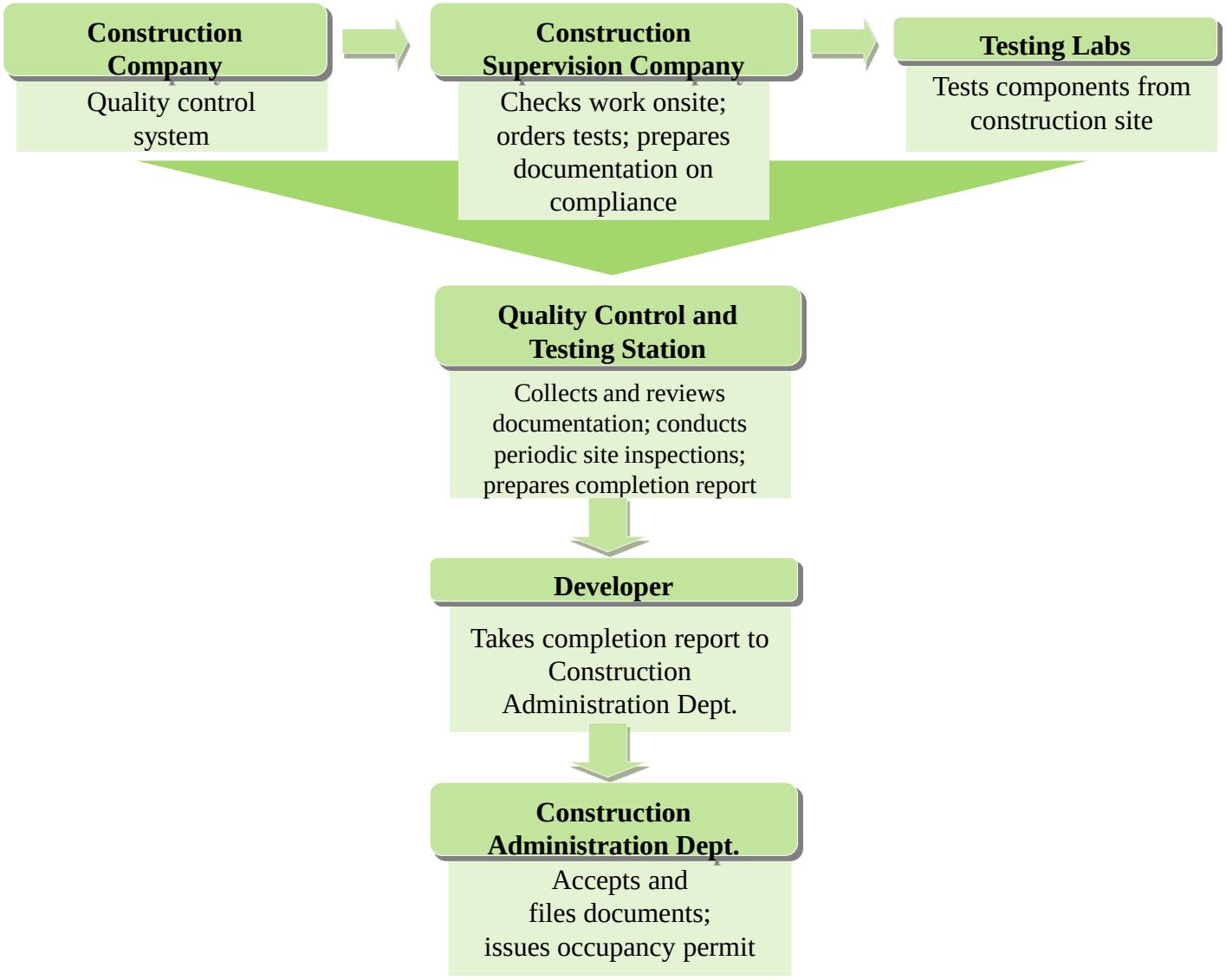
- Understanding building trends, stakeholders
- Making enforceable codes
  - Who will enforce?
  - How will buildings learn of and interpret requirements?
  - How can we build capacity and make this easy?
- Challenges of small buildings
  - Variety of buildings
  - Limited capacity
  - Wide variety of construction materials

Enforcement System

- Key code enforcement steps in Chinese building construction



Construction site inspection roles



Lessons Learned

For China

- Enforcement in smaller towns and rural areas.
- Testing and ratings.
- Easier access to training and more user-friendly information.
- Increasingly rigorous codes.

For the U.S.

- The extensive use of third parties in code compliance.
- The “industrialization” of the construction and code compliance processes.
- An example of integrating design and code compliance software.

Market Opportunities

- Codes help build demand for a range of building energy efficiency products like insulation, efficient windows and lighting.
- New post-occupancy and ‘stretch’ code requirements are also building the market for services like building commissioning, energy audits, and performance contracting.
- Because of their large impact on market deployment, codes can also make it easier for companies to obtain value from innovation and R&D.

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Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

Advanced Building Decision Tools Collaboration

Wei Feng
劳伦斯伯克利国家实验室
2013年9月

Advanced Building Decision Tools Collaboration

- **COMBAT: Commercial Building Analysis Tool for Energy Efficiency Retrofit**
- **VisualEPlus: A bilingual building simulation tool using *EnergyPlus***
- **DER-CAM: Distributed Energy Resource Customer Adoption Model**

Commercial Building Analysis Tool for Energy-Efficient Retrofits (COMBAT)

Purpose: *Analyze commercial building retrofit energy savings and investment cost-effectiveness*

Related Tools: *EnergyPlus*

Audience: *Retrofit practitioners, policy makers, facility managers, and engineers (w/o building energy modeling knowledge)*

Developer(s): *China Energy Group at LBNL*

Availability: *http://china.lbl.gov/COMBAT_Tool ,English and Chinese, SI unit. Funded by Energy Foundation, Schneider-Electric, U.S. DOE.*

Limitations: *Only applies to China's hot summer cold winter climate zone with hotel and shopping mall building types*

Impacts summary: *Trained 50+ people in Shanghai in 2012 including key policy makers. Retrofit of shopping mall or hotel can yield 20%~30% energy savings in Shanghai.*

Potential: *More building types and climate zones could be added to the tool. Work with universities (such as Tongji University) to develop and disseminate it.*

Commercial Buildings Retrofit and COMBAT

Background:

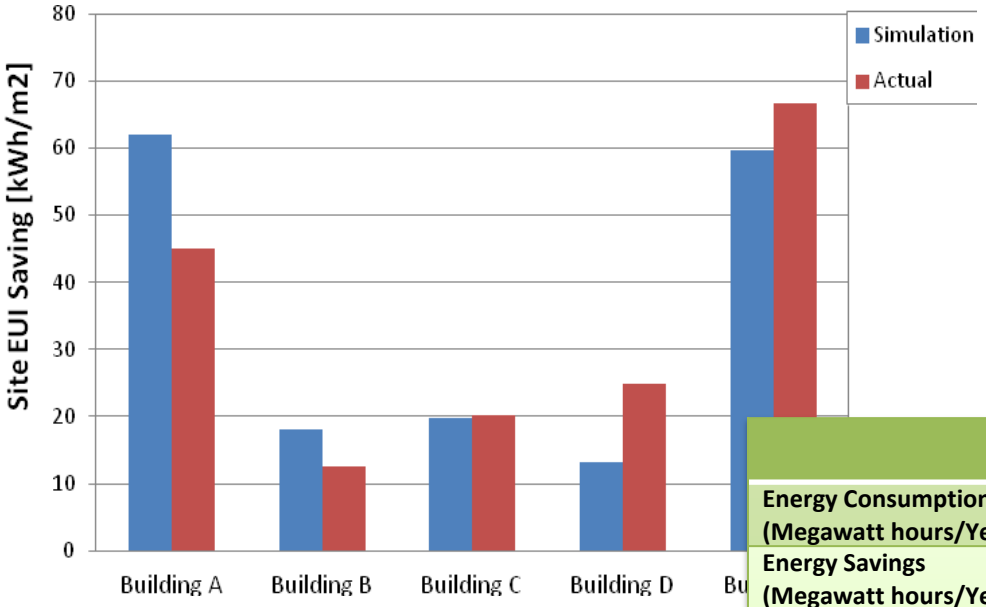
- Commercial (public) buildings retrofit is targeted to save 14 Mtce in China's 12th FYP.
- Central and local governments create large incentive programs for commercial building retrofit
- In Shanghai's Changning district, over 100 buildings need retrofit in the 12th FYP
- No tool existed for quick assessment of energy savings and investment cost-effective as the results of retrofit.

Current impacts:

- COMBAT is developed with collaboration from Tongji University and NRDC Beijing office. The tool has been used for analysis in a few retrofit projects in Shanghai. A training workshop was held in Shanghai in 2012 to train Chinese local government officials, U.S. companies, and Chinese ESCOs on the use of the tool for their retrofit analysis.
- Provide training and work with ECP-China, U.S. companies (e.g. Trane, Autodesk, Schneider Electric) and Chinese ESCOs
- **Selected collaborators:** Tongji University, NRDC Beijing office, Shanghai Energy Conservation and Supervision Center
- **Selected project using COMBAT:** 4 shopping malls and 2 hotels have used COMBAT and compared its calculation results with measured results. More buildings are using the tool in Shanghai's Changning district.

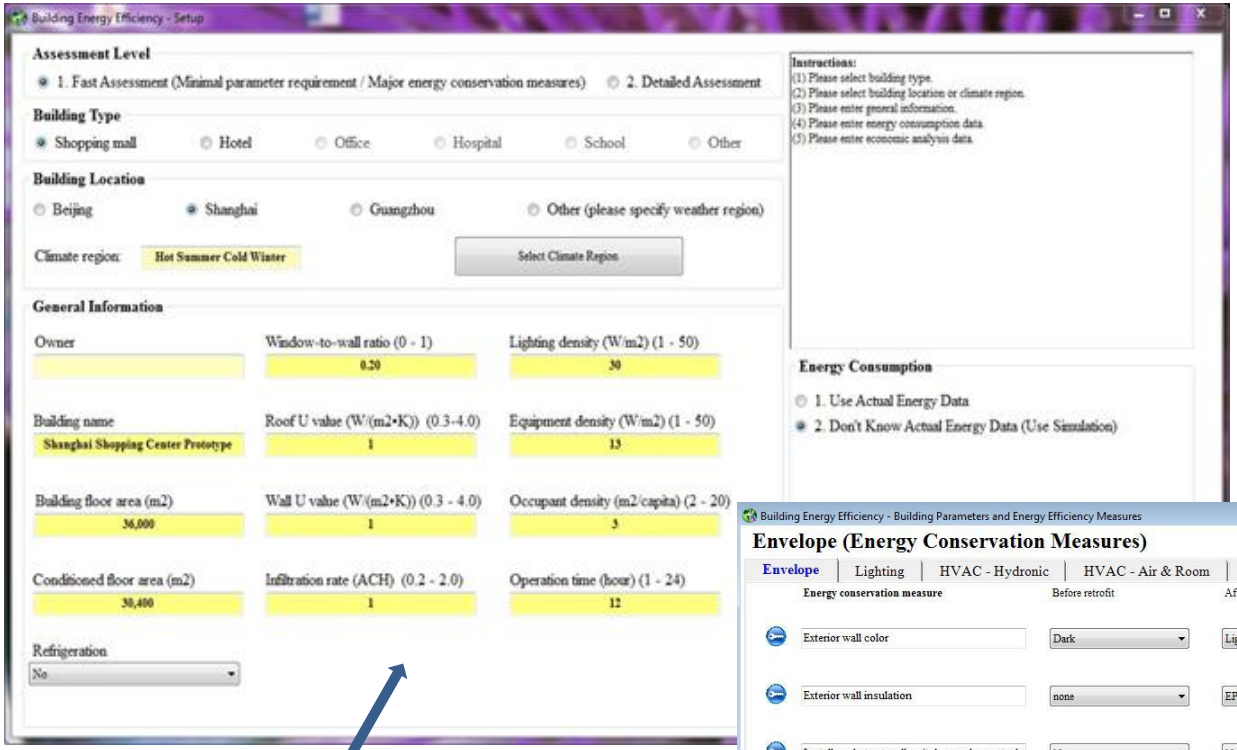
COMBAT: Verifications of Chinese Buildings

- 4 shopping malls and 1 hotel
- Calculated savings in line with measured data



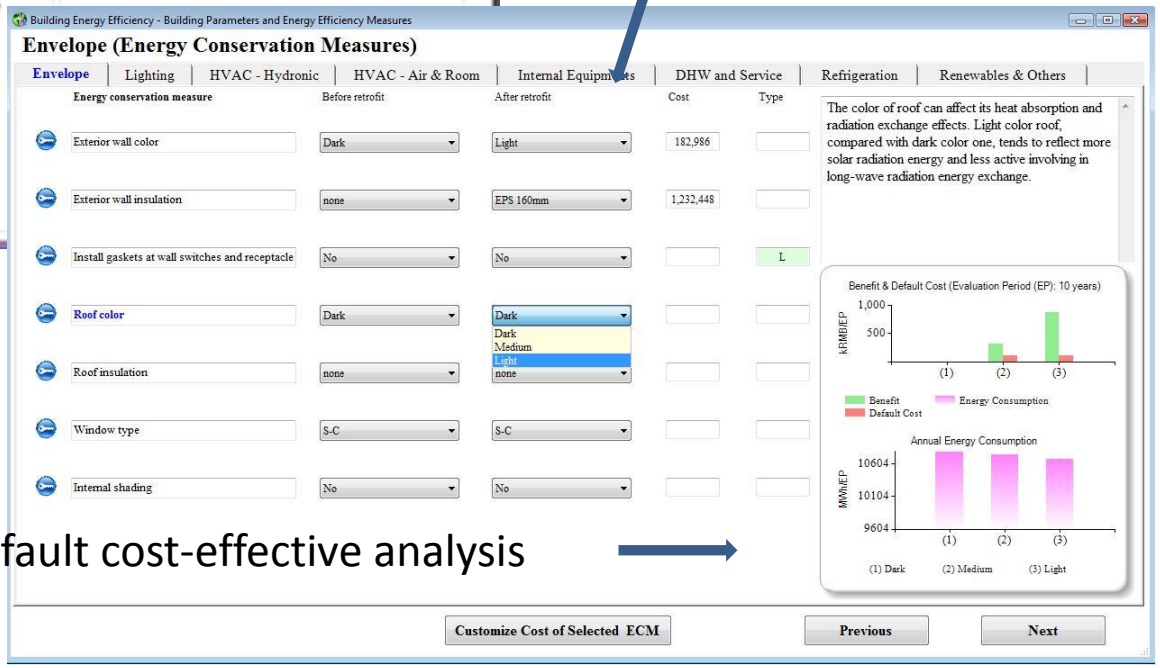
	Building A	Building B	Building C	Building D	Building E
Energy Consumption Before Retrofit (Megawatt hours/Year)	38,847	33,512	73,044	8,287	14,229
Energy Savings (Megawatt hours/Year)					
Calculated	7,902	1,950	4,952	419	3,337
Actual	5,737	1,364	5,033	795	3,723
Relative Error	-37.7%	-43.0%	1.6%	47.3%	10.4%
Energy Saving Rates					
Calculated	20.3%	5.8%	6.8%	5.1%	23.5%
Actual	14.8%	4.1%	6.9%	9.6%	26.2%
Absolute Error	-5.6%	-1.7%	0.1%	4.5%	2.7%
Economic Benefits (RMB/Year)					
Calculated	6,299,256	1,506,165	3,825,256	323,361.4	3,461,041
Actual	5,378,438	1,278,750	4,718,438	745,312.5	3,350,700
Relative Error	-17.1%	-17.8%	18.9%	56.6%	-3.3%

COMBAT Demonstration: Inputs



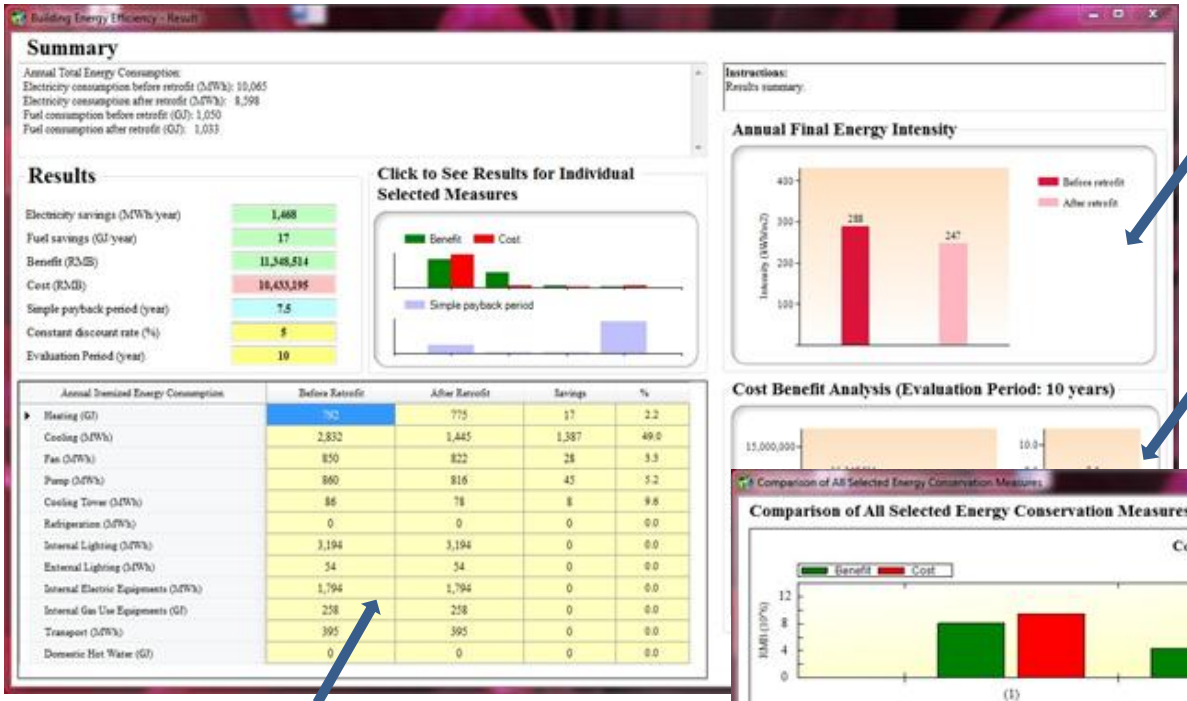
Building characteristics inputs

Retrofit measure inputs



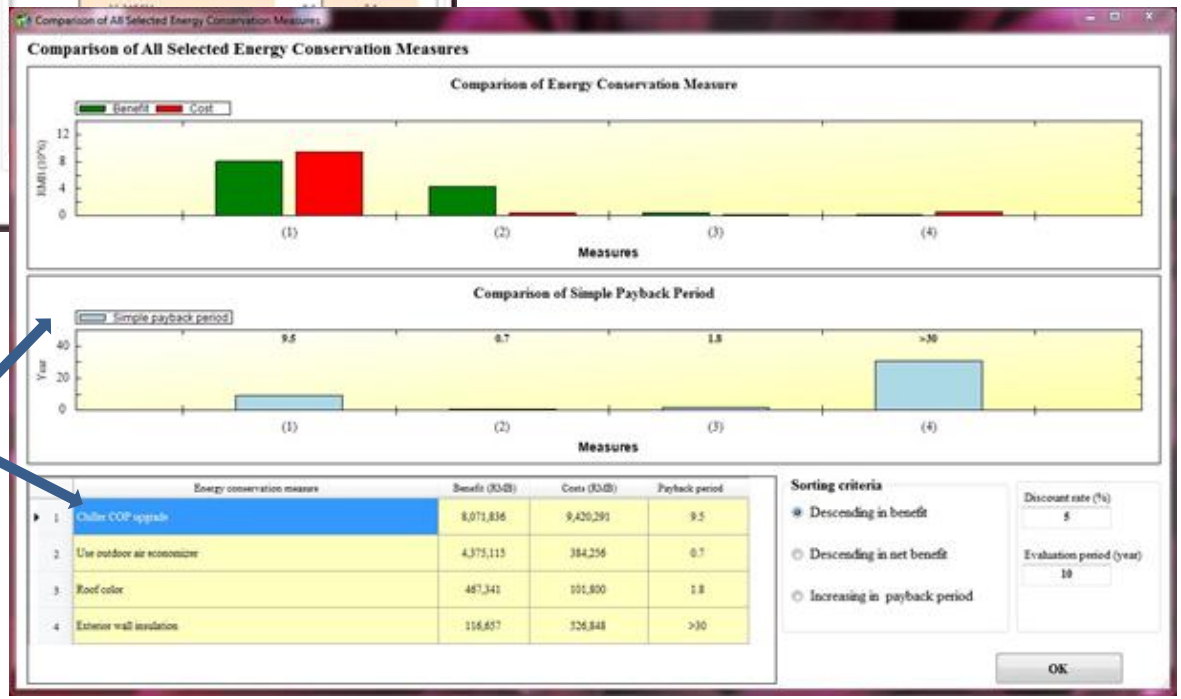
Default cost-effective analysis

COMBAT Demonstration: Outputs



Energy savings analysis

Payback analysis



Energy savings analysis

Individual measure's cost-effective analysis

Distributed Energy Resources Customer Adoption Model (DER-CAM)

Purpose: *produces optimal investment decisions and dispatch for technologies as fuel cells, PV, solar thermal, electric / heat storage, heat pumps, EVs, etc.; it minimizes annual energy costs, CO_2 emissions, or multiple objectives of providing services to buildings (~100-2000 kW peak)*

Related Tools: *none*

Users: *more than 350 DER-CAM web-clients to date for the simple investment version (multiple versions with different copyrights are available at http://der.lbl.gov/der-cam/how-access-der-cam, stochastic versions for EVS and other technologies as PV exist or are currently under design)*

Developer(s): *developed for 12 years by LBNL, collaboration with China and other countries*

Availability: *simplified investment web version via https://microgrids2.lbl.gov/ (WebOpt); English and Chinese, SI units. Funded by US DOE, CEC*

Limitations: *not all features are provided in the simplified web version, in general more work is needed on passive measures*

Impacts summary: *40 online accounts from China, 73 online accounts from U.S.; University and teaching, building managers and operators, cost reductions up to 30% and CO_2 reductions up to 100% (in ZNEB mode) due to well guided decisions (see next page)*

Potential: *Expand functionality to be able to develop a district energy system optimization toolkit for China's low carbon district/city energy system analysis; cheap and simple real time building management service over the web (multiple requests from national and international companies)*

Distributed Energy Research and Impacts

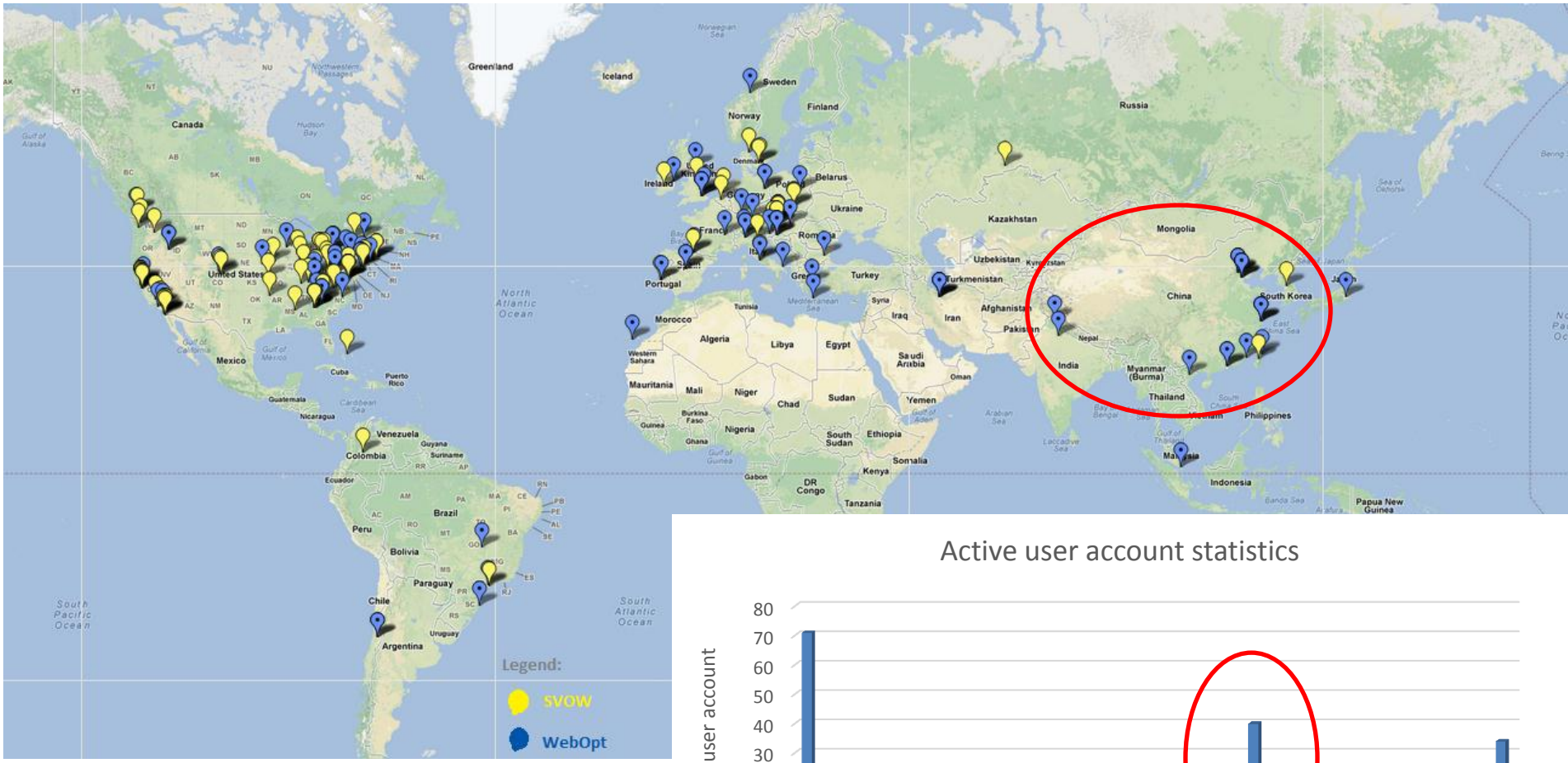
Background:

- China's 12th FYP highlights CHP and other distributed energy as one of its important energy goals
- 1000 distributed natural gas generation in the 12th FYP (each less than 5MW)
- NEA's 12th FYP states that 30 national-level microgrid demonstration projects will be built by the end of 2015
- China State Grid's new policy on distributed energy grid connection (less than 6MW)

Current impacts:

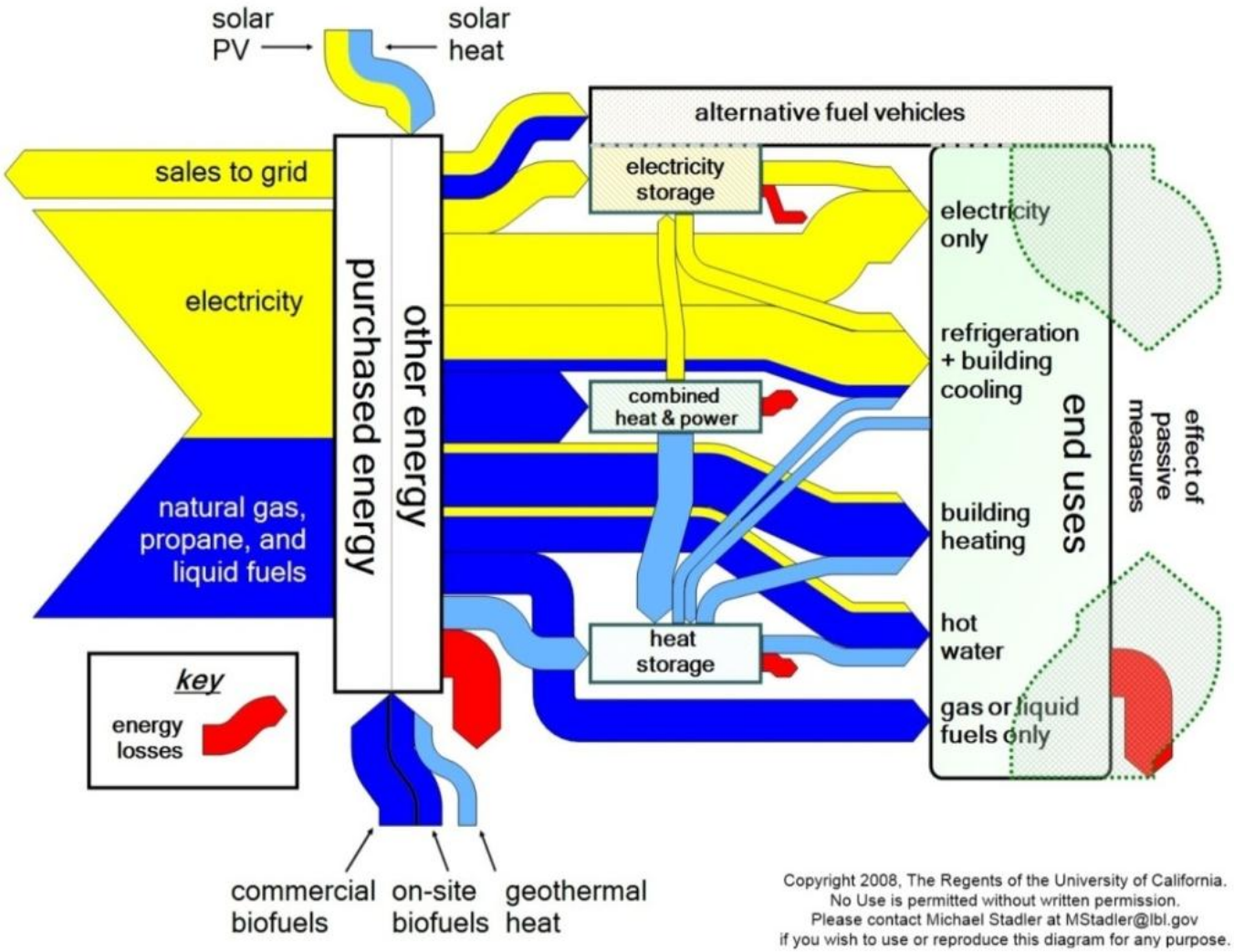
- LBNL is working with the Chinese Academy of Science (CAS) – Institute of Electrical Engineering (IEE), and NEA on the development criteria and evaluation methods for 12th FYP's 30 national-level microgrid demonstration projects by using the DER-CAM tool developed by LBNL.
- Work with ECP-China and U.S. DER companies (e.g. DOW, ICF, Capstone, Honeywell) on China projects.
- **Selected collaborators:** Tianjin University, Tongji University, Shanghai Energy Conservation and Supervision Center, Shenzhen Microgrid Lab, Shenzhen Institute of Building Research, CAS-IEE, Xiamen University, Hefei University
- **Selected DER and microgrid projects LBNL is working on using DER-CAM:** Shanghai Changning Central hospital, DongAo Island (Zhuhai, Guangdong), Tianjin University Microgrid Lab (MOST's 973 project), Shenzhen Microgrid Lab, Shanghai Chongming Island microgrid project

DER-CAM : Active User Accounts Around the World

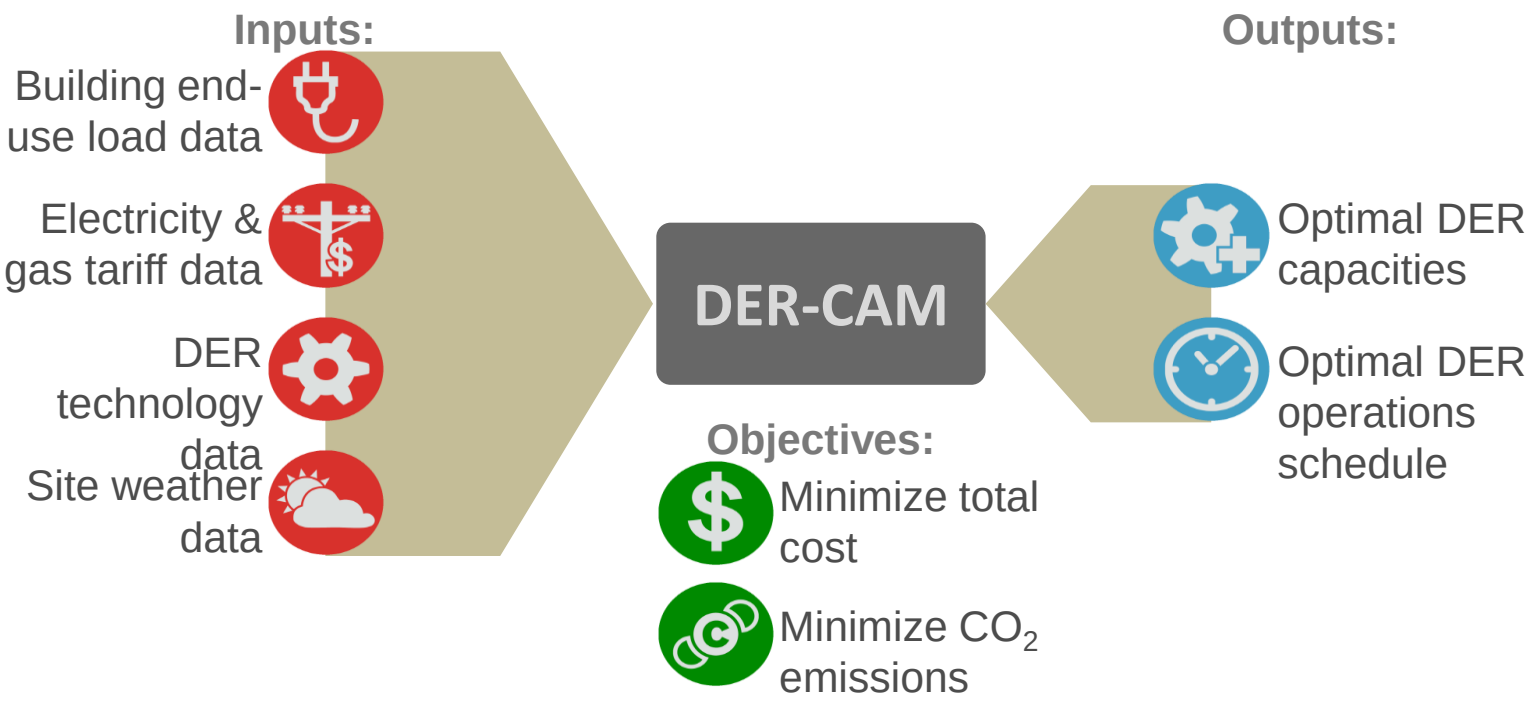


DER-CAM Fundamentals -- Sankey Diagram

Sankey diagram shows how distributed energy is transport, converted and balanced



DER-CAM Demonstration: Inputs



- **Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs
- **Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs

DER-CAM Demonstration: Outputs

VisualEPlus 2.0 Introduction

Purpose: *a GUI in Chinese and English for the **EnergyPlus** program, focusing on graphical modeling of HVAC system, and analysis of output results.*

Related Tools: *no other similar GUI in Chinese; intended to be used in conjunction with **Open Studio** for building modeling.*

Users: *building energy practitioners, academia, and students interested in building energy simulation with **EnergyPlus**, particularly in China.*

Developer(s): *Tongji University (lead) and Shandong University in collaboration with White Box Technologies, Inc. and ORNL.*

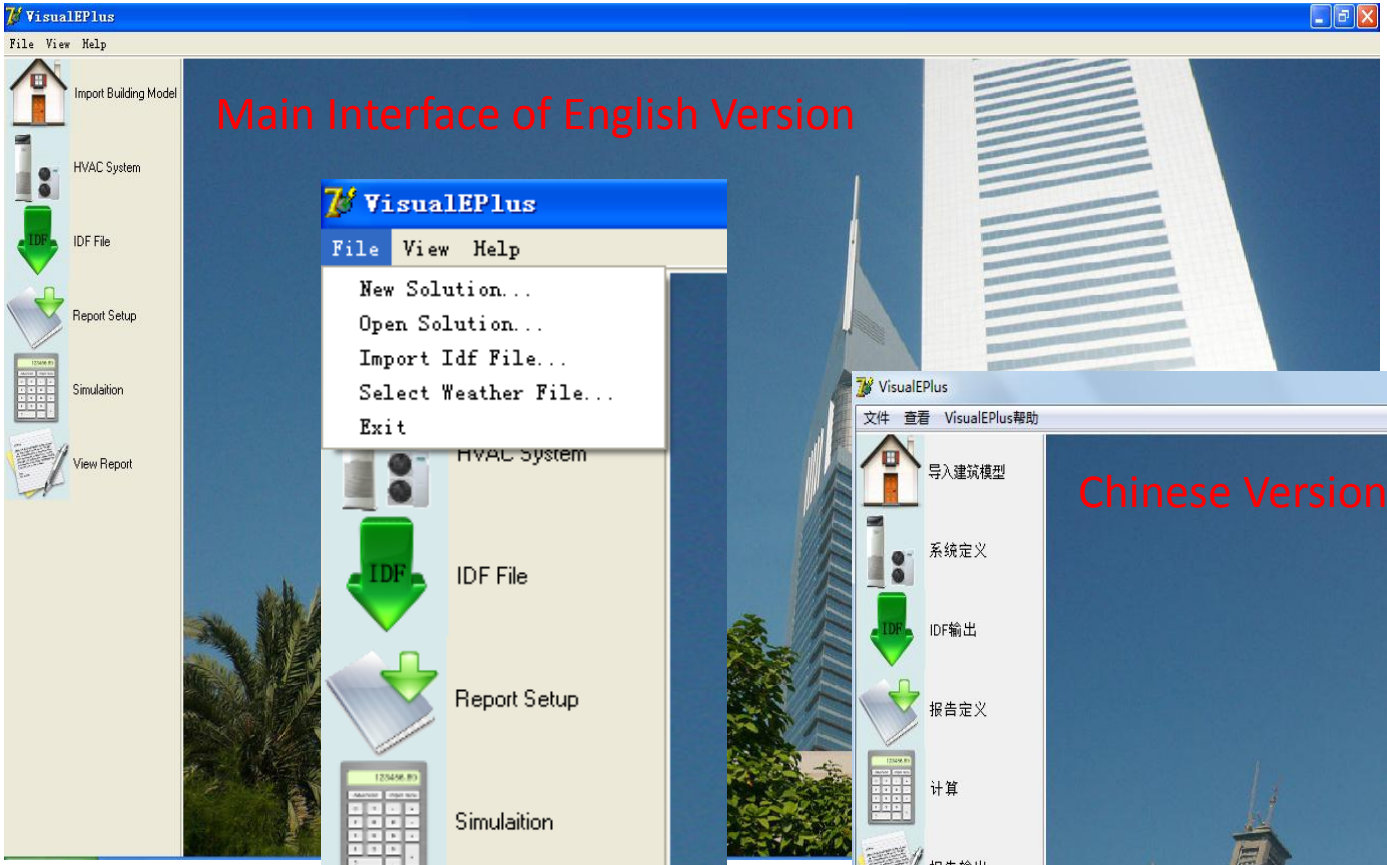
Availability: *Chinese version launched November 2012 http://bsim.tongji.edu.cn/custom.asp?mk=1&id=244; English version planned launch June 2013 to be available at www.whiteboxtechnologies.com and ORNL for users outside of China.*

Limitations: *Simulation GUIs are very complicated software**;** to limit effort and meet greatest need, **VisualEPlus 2.0** concentrates on two areas only – HVAC modeling and report analysis; program is still "buggy" with many areas for improvement.*

Impacts: ***VisualEPlus** has been introduced at conferences in China, US and Canada starting since 2009 (**HVAC Simulation Seminar** Beijing Nov 2009, **SimBuild 2010** New York Aug 2010, **IMECE 2010** Vancouver Nov 2010**, ASim2012** Shanghai Nov 2012).*

Potential: ***VisualEPlus** makes **EnergyPlus** acceptable to the Chinese building energy modeling community, which can then play an important role in building energy efficiency design, standards development, and R&D in China, just as **EnergyPlus** does in the US.*

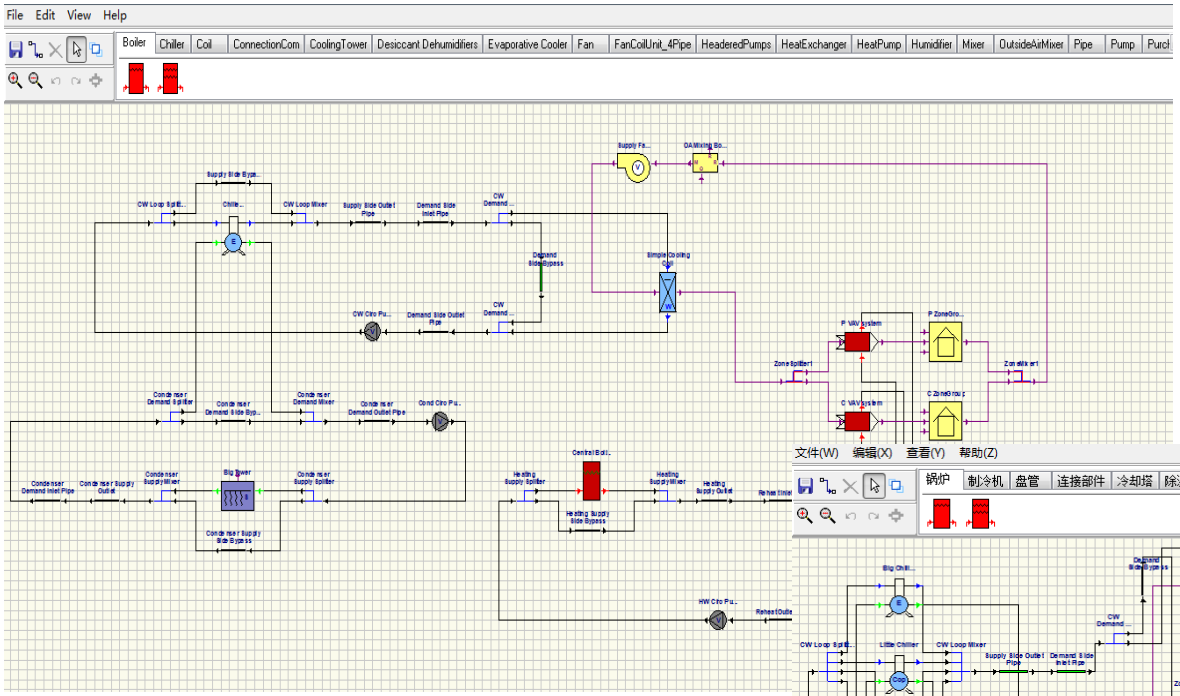
VisualEPlus2.0 Demonstration: Inputs



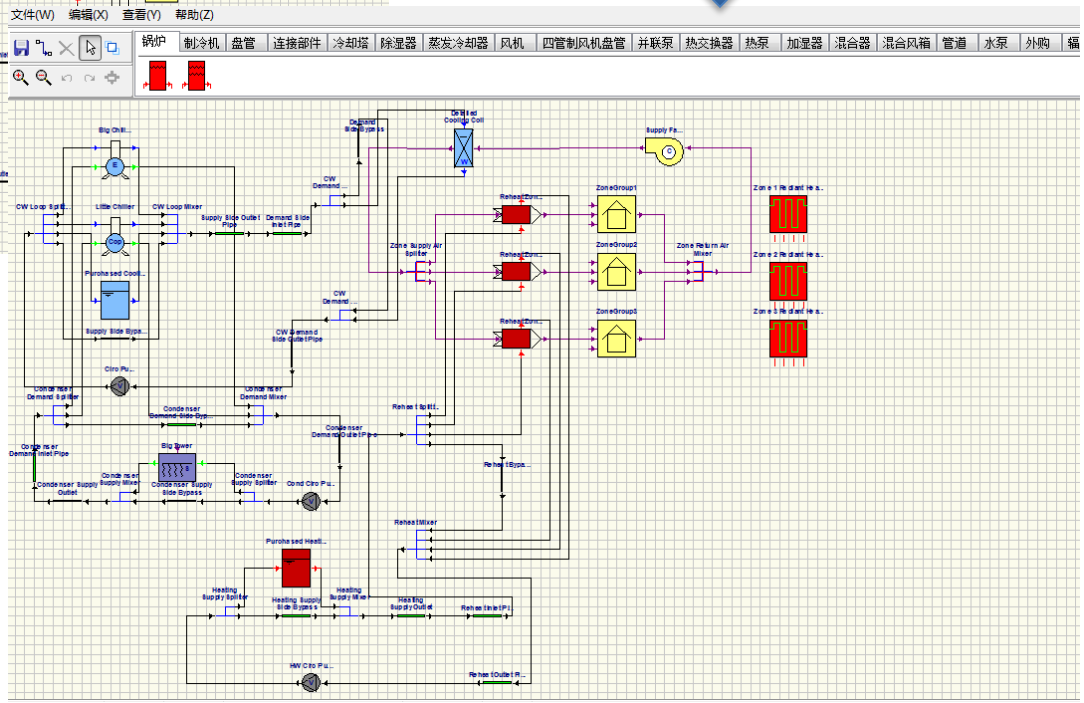
Drop-down Menu for Operation Procedures

Building model needs to be generated by other programs (i.e., Open Studio) & loaded into VisualEPlus 2.0

VisualEPlus2.0 Demonstration: HVAC Modeling GUI



English Menu



VisualEPlus 用户手册

User Menu

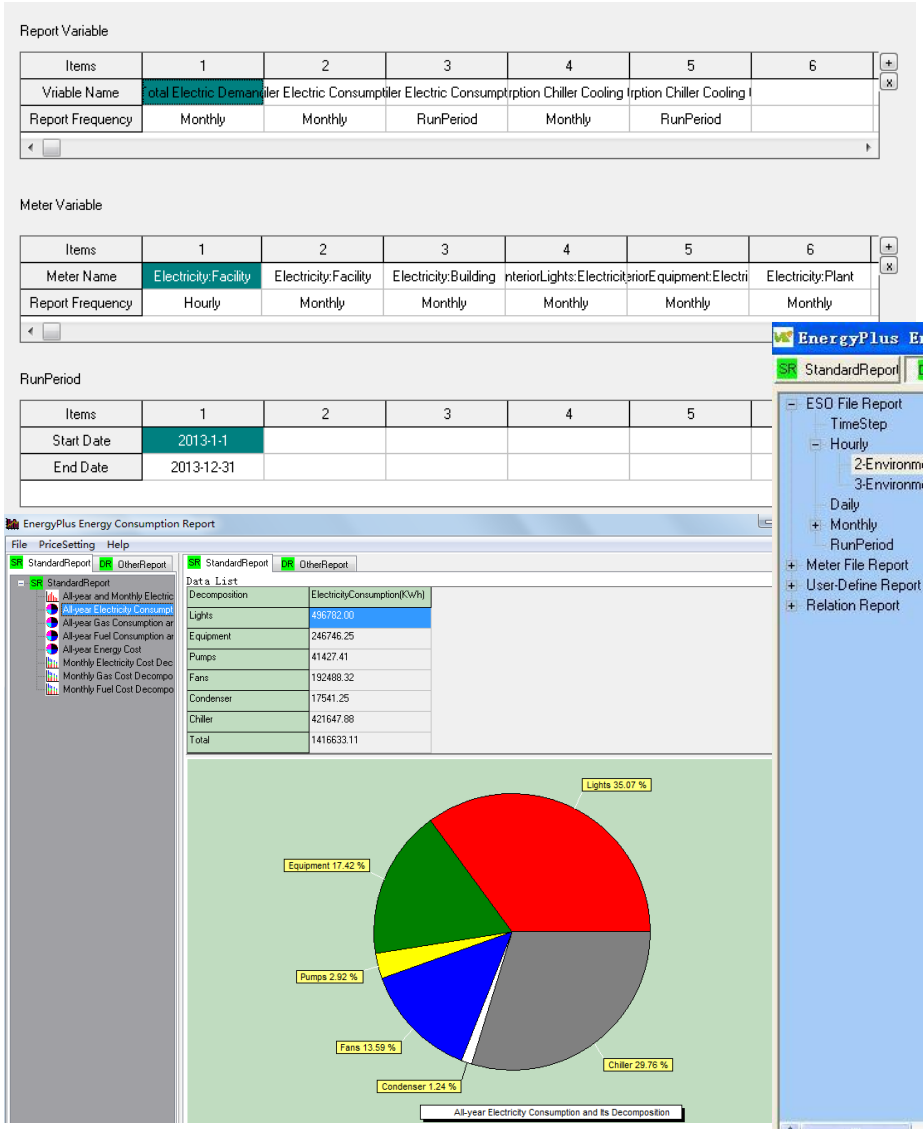
版本：2.0

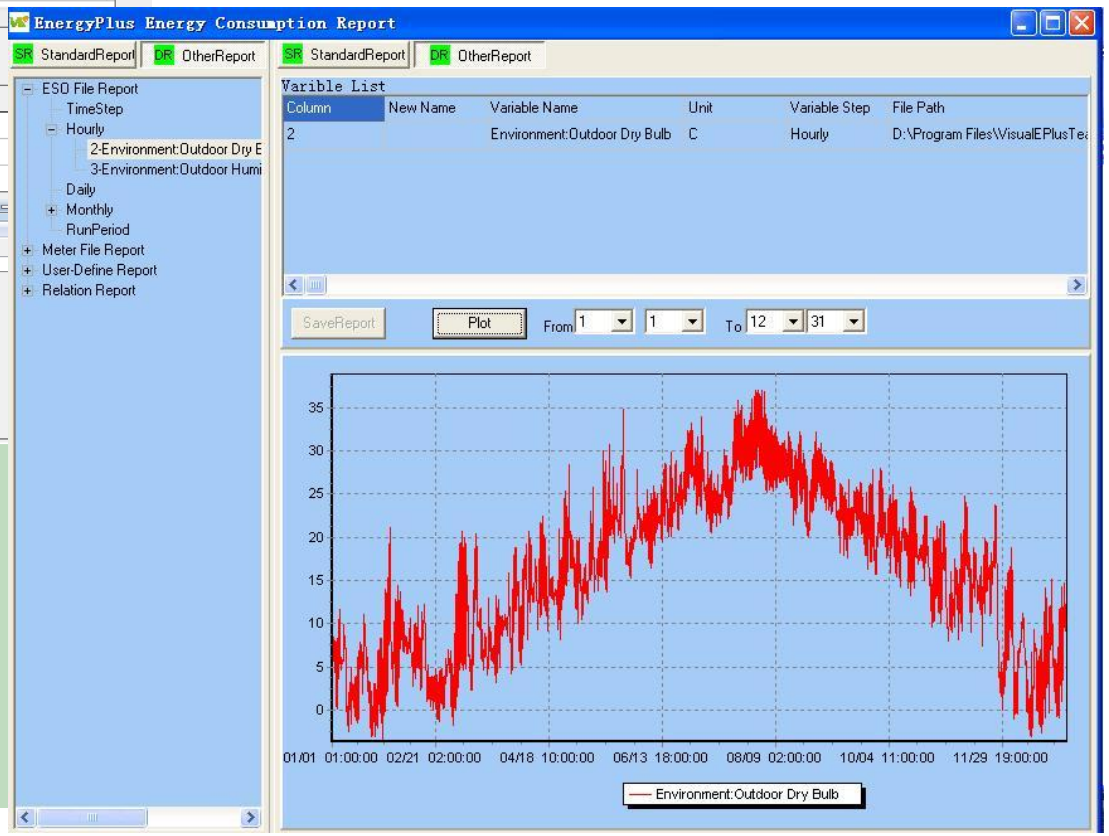
Chinese Interface

- "Drag-and-drop" style graphical modeling for HVAC systems
- 109 HVAC components in 28 categories
- 11 HVAC templates

VisualEPlus2.0 Demonstration: Output

Visualize simulation result in both standard and customized reports for user selected variables, during user selected time periods, and at various time intervals





Thank You!

Questions?